New Product Strategy in Small High Technology Firms: A Pilot Study

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May, 1984
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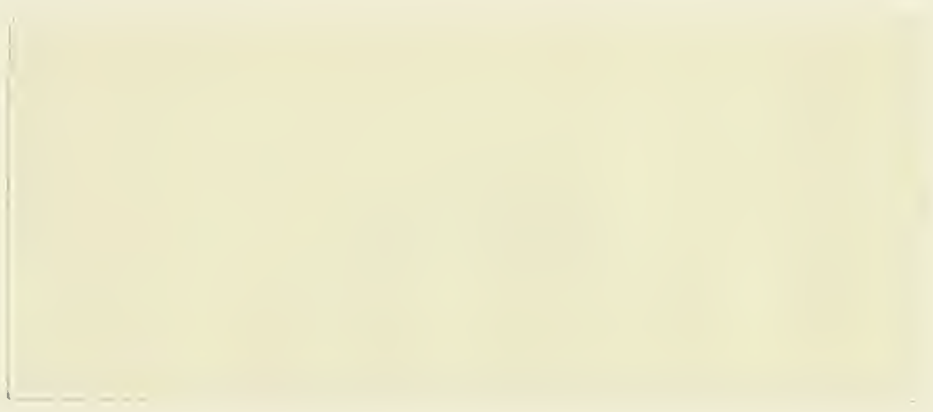

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Abstract

A pilot test is reported on the relationship between the degree of "newness" within a firm's portfolio of products and the firm's economic success. The embodied technology and market applications newness is measured in the product sequences of a sample of small high technology companies. The degree of "strategic focus" is shown to relate directly to corporate growth in that firms with more concentrated technological and market orientation outperform other companies. The evidence suggests some skewing in this relationship in that some "newness" is better than no "newness".

NEW PRODUCT STRATEGY IN SMALL HIGH TECHNOLOGY FIRMS: A PILOT STUDY

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This article presents a pilot study of an empirical method to examine the effectiveness of new product strategies in small high technology firms. The purpose of this research is to determine whether there is a relationship between the degree of "newness" within a firm's portfolio of products, in terms of the embodied technology and market applications, and the firm's economic success. Specifically, does the degree of "strategic focus" exhibited by small high technology companies affect corporate growth in a systematic manner?

Research Background

Conceptual Framework

Traditional studies of new product success have usually focused on multi-company samples of individual products or paired product comparisons. Calantone and Cooper (1981), for example, reported on 195 new product cases from 103 firms, finding 18 cluster dimensions that related to individual success. Marquis (1969),

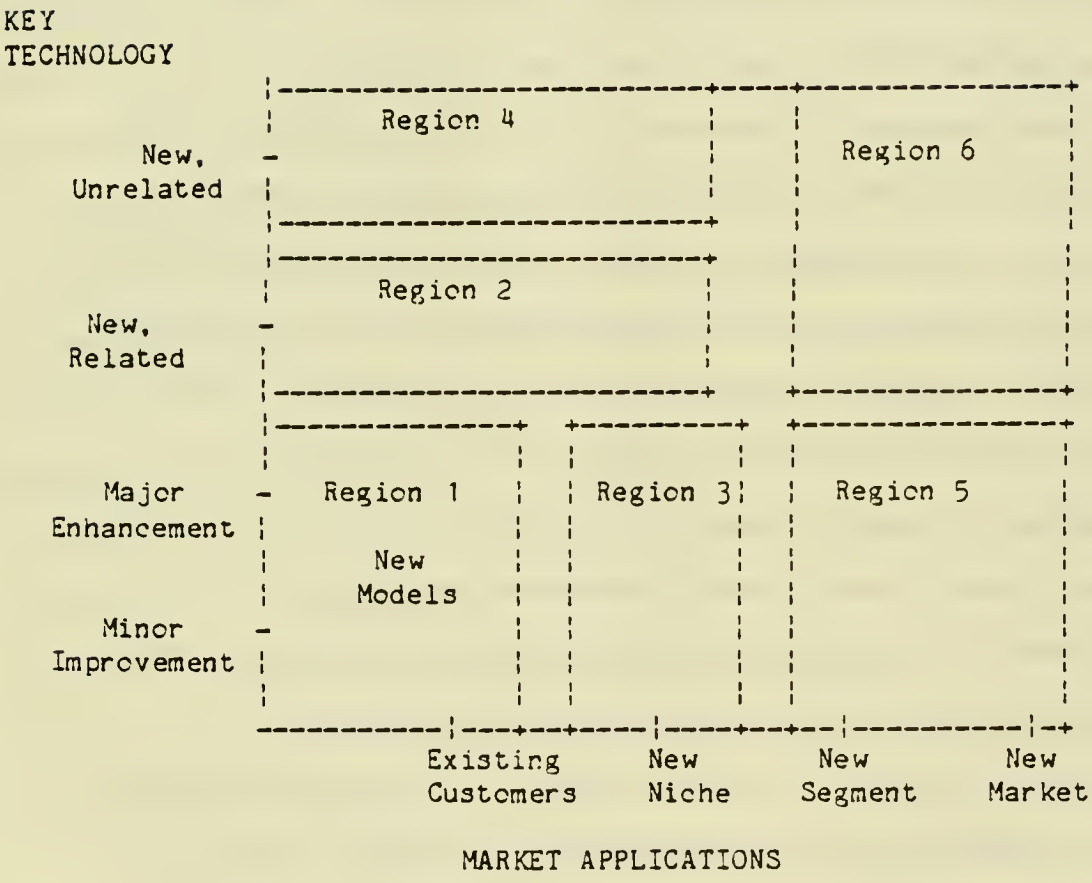
Rothwell et al. (1974), and Cooper (1979) reported similar analyses on large samples of single products.

But little research has focused on examining the sequences of product releases that become, eventually, a firm's product line or multi-product portfolio. Does one pattern of sequential product development, identified in this article as a "new product strategy", lead to different corporate success than another pattern?

New product strategy requires a historical base for assessment. Only an understanding of a firm's past product activities can provide the full context by which to evaluate the challenges posed by its next set of new products. In turn, this comparison of the present to the past may be performed along two basic dimensions. The first is the newness of the technology within the new product relative to technology(ies) already developed by the firm. The second dimension is the newness of the market application for which the new product is targeted compared with the users of past products. The pairing of embodied technology and market application for the examination of new product strategy is an idea used previously by many authors, including Johnson and Jones (1957) among the earliest, and more prominently by Rumelt (1972). Each of the two dimensions incorporates a set of factors. For example, the degree of newness in market application includes levels of newness regarding product packaging, distribution channels, and support mechanisms. As each new product comes on stream, the cumulative body of the firm's technology and market experience grows accordingly, and is that much broader for the evaluation of the next new product effort. This framework is shown in Exhibit 1.

Exhibit 1

The Product Innovation Grid



For the technological dimension of Exhibit 1, the critical unit of analysis identified is the "key core technology(ies)" of a product. A core technology is a discrete, unique set of skills or techniques which finds application within a product or service. A given product embodies at least one identifiable core technology, and it may include several or more separate technologies. However, not all core technologies embodied within a product have the same impact upon the firm's competitive advantage. Accordingly, those particular core technologies which provide the firm with a proprietary, competitive edge and differentiate it from other companies making similar or substitute products have been identified as key core technologies (Ketteringham and White, 1983). Key core technologies can be distinguished from other technologies used by the firm that are commonly available in the marketplace as components. This latter, more broadly available group of core technologies are referred to as "base technologies". A firm that is engaged in an industry characterized by rapidly advancing technology typically concentrates on one or more specific key core technologies, and by packaging or integrating it with a variety of component base technologies, generates its final product. The key core technology becomes the basis for the "value added" of the firm. Clearly, this process occurs only in those firms that undertake their own product development and are not simply sales or support organizations.

Therefore, the differentiating element along the technological dimension of a firm's product portfolio is the degree to which each new product entails changes to the embodied key core technology of past products. This level of change runs along a continuous range of

expended resources and effort. However, for the purposes of research, specific levels of change or newness can be identified. The spaces in the diagram between "regions" suggest areas of overlap or ambiguity.

The first two levels identified are "minor improvement" and "major enhancement" to a key core technology that the firm had developed some time in the past. Major enhancement is often achieved through the addition of new base technologies to a product line. It often requires a substantial development effort. By adding new components or subsystems, the firm can leverage its existing key technology into new product/market areas without having to develop additional new technologies of its own. The third level of technological newness is the development of a "new, related" key core technology, "related" by virtue of either sharing a product application in which the firm is presently involved or being combinable with an existing key technology into a wholly new product application. The development of a "new, but unrelated" key technology presents no such opportunity for combination with the firm's existing product technology. This is the most extreme level of technological newness.

A schema for identifying levels of newness in the market application dimension of Exhibit 1 has been adapted from the competitive structure model of Urban, Johnson, and Brudnick (1979). This model, shown by example in Exhibit 2, segments a market into a hierarchical tree structure by assigning possible product attributes to specific tree branches. These branches are defined by an analysis of the types and effects of product usage and the characteristics of

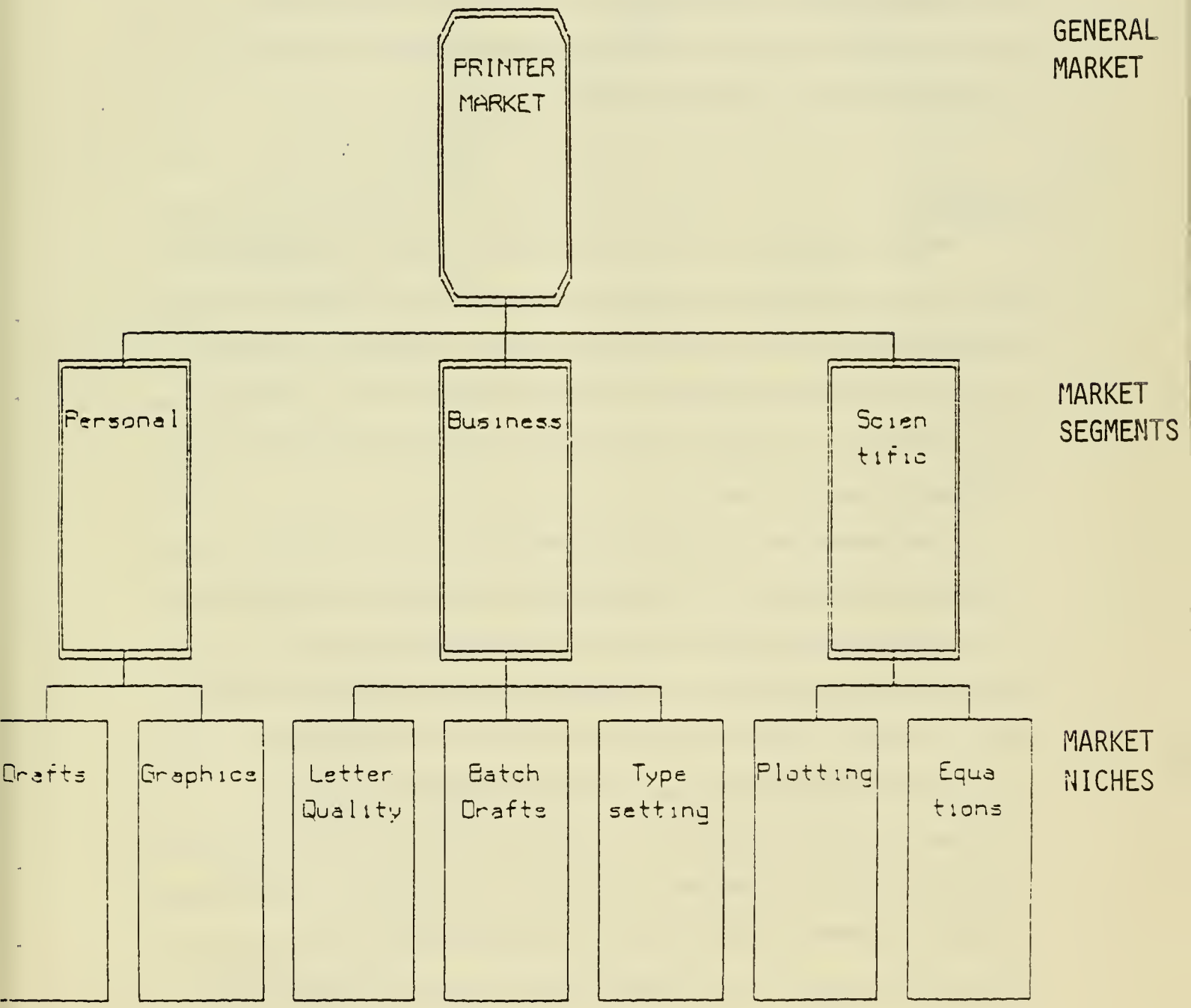
users. Urban et al. show that the significance of individual tree branches can be established by measuring the probability of purchase under "forced choice" testing of consumers.

In the conceptual adaptation of this model to the present pilot research, the market tree structure(s) for a firm's products is derived by extensive discussion with the interviewees. However, individual tree branches are not statistically tested by random sampling of consumers of the firm's products, as had been done by Urban et al. Additionally, the layers of the market structure are restricted to three generic levels: the general market, segments within the market, and niches within each segment. This taxonomy captures most of the degrees of newness in the target markets for new products. Since the market structures facing a firm can change over time, the degree of market newness assessed for a particular product is based on the "current" structure at the time of the new product's release. As illustration, the market tree in Exhibit 2 was developed with the founder of a printer company that is part of the sample of this pilot study.

The intersections of technological and market newness on the Exhibit 1 grid, sixteen in all, can be grouped into regions of new product activity. Region 1 represents the release of new versions or models of current product lines, requiring some degree of enhancement to existing key core technology. In Region 2, the firm broadens its activities in an existing, or to a closely related, product/market by developing a new key technology that is combined in some fashion with the firm's existing technology. Forward integration would be an example of this type of new product activity. Region 3, on the other

Exhibit 2

The Hierarchical Market Structure



hand, is characterized by adaptive innovation. Here, the firm applies its existing technology to new sets of users who are closely related to current ones. In Region 4, a high degree of technological newness is combined with relatively low market newness. This is a "customer-bound" focus where the firm tries to make markedly different products for a single set of customers. Region 5, on the other hand, represents extreme instances of adaptive innovation. Finally, new products that require the largest amounts of technical and market diversification fall within Region 6.

Hypothesis

The general purpose of the research is to examine the possible relationship between patterns of new product strategy and the economic performance of the firm. The authors hypothesize that high technology firms which exhibit a high degree of strategic focus in their new product development activities are more successful than those which have less focus.

The extreme of a focused strategy would be represented by a firm that without fail takes small steps of incremental improvement in a single key technology for one basic customer set. At first glance, this may seem the least risky of strategies because the firm takes no chances in exploring new technological areas or market applications for its products. However, a dogged faith in the continued viability of a single technology/customer set could, over time, prove to be a risky course of action. The opposite extreme strategy is a firm that, with each new product introduced, consistently attempts to implement radically new technologies for

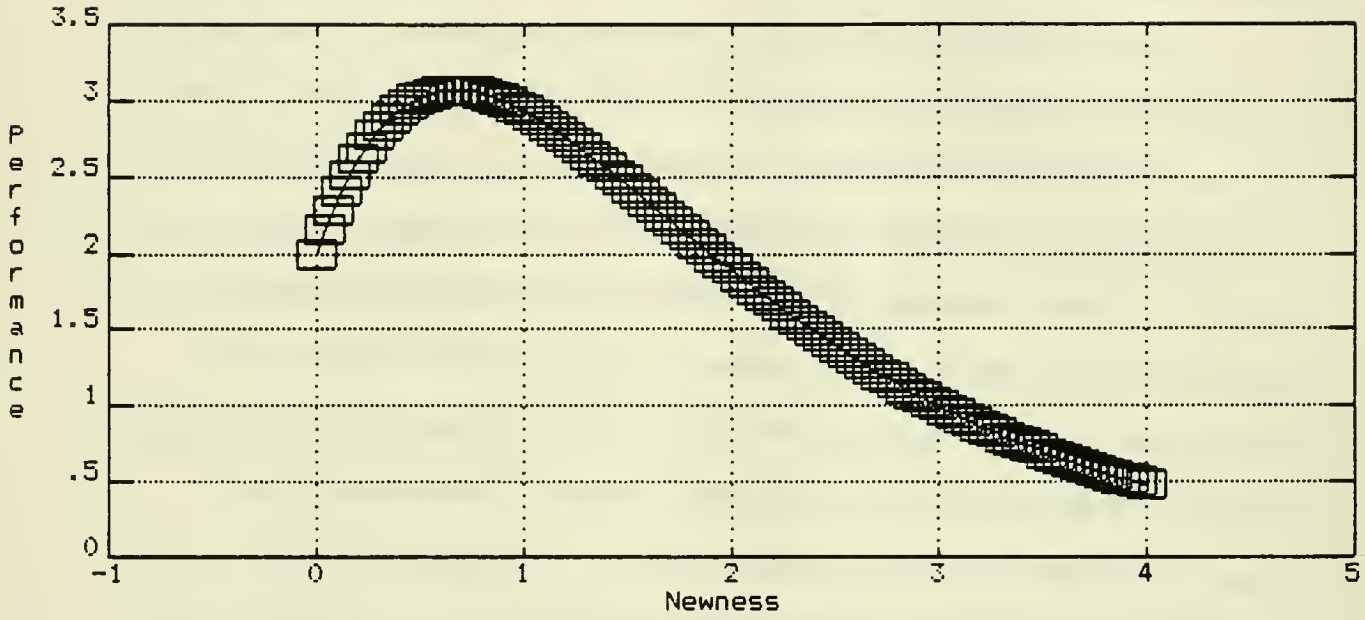
substantially different applications than those with which it has previous experience. Between these limits lies the gamut of possible strategic variation in degree of change in technology and market applications.

The hypothesized relationship between the degree of focus in new product strategy and performance in small technology-based firms follows a bell-shaped curve that is skewed to the left (Exhibit 3). The most successful firms are posited to be those that on average pursue a focused strategy, with relatively low levels of cumulative product newness, but which, in several or more critical new product development efforts, have substantially enhanced their existing key core technology to exploit new market niches or segments. Those firms which remain narrowly focused and never undertake major technological enhancement, nor the application of their technology to new related niches or segments, may achieve a certain degree of economic success by virtue of their resource concentration and expertise, but it is hypothesized that their growth potential will remain limited. On the other side of the coin, those firms that exhibit high degrees of product diversity will be trapped into trying to achieve too much with too little in terms of practical working experience with both the new technology and marketplace demanded by their new products.

The hypothesis suggests that a firm may undertake either substantial technological improvements in a related sense for its current customer base or try to reach new related applications with enhanced existing technology, but not both types of product newness at the same time. If a firm cannot remain stagnant, is it better, in

Exhibit 3

Newness versus Performance



assessing relative risk of new product moves, to try to learn new complementary technologies to substantially enhance a product line for essentially the same sets of customers, or to try to reach new markets that will require only customization of existing technology? In other words, is it easier to learn new technology or new markets?

We posit that for the small technology-based firm, mastering new, related key technology is on average a more certain, achievable task (such as in backward integration) than is penetrating new market niches or segments with customized existing technology. The reasoning behind this assertion rests upon the very character of the subject organization: long on technology skills, often lying with the founders, and often short on the marketing skills and resources required successfully to target, distribute product, and otherwise support new customer sets, even those closely related to the firm's existing ones. In terms of the conceptual grid shown in Exhibit 1, the authors hypothesized stronger performance for those firms whose new product activities gnerated products characterized as "minor improvements" or "major enhancements" in the technological dimension, and targeted for "existing customers" or "new market niches".

The strategic direction suggested by the authors' "strategic focus" hypothesis runs counter to the tendency of American businesses to pursue diversity in their product technologies, as described by Rosenbloom and Abernathy (1982). "Since the 1950s, a penchant for diversification has led U.S. firms away from their core technologies and markets." Part of the justification behind this asserted trend lies in corporate portfolio theory, which argues that overall risk can be minimized by having assets spread across a variety of

product/market areas. Heavily oversold "learning curve theory" has also played a role in the tendency observed by Rosenbloom and Abernathy. By placing a high priority on major increases in manufacturing output to achieve economies of scale, management may forego the flexibility needed to implement new, innovative features in existing product lines, a danger documented in the automobile industry by Abernathy and Wayne (1977). Product development resources must, by default, be allocated primarily to other, newer business areas.

"Strategic focus", on the other hand, implies a level of concentration on a key technology area which, on average, may be the most important factor in the firm's effort to compete in the world marketplace. This source of competitive advantage seems even more critical for the particular type of company examined in this research: the small high technology firm. That firm characteristically has limited financial resources, may well have relatively undeveloped market strength, but may possess advanced technology (Roberts, 1980).

The Sample

In development of a pilot study of this hypothesis, the framework described above was applied to a group of ten small high technology firms and their 79 products, a subset of a larger sample developed for a multi-subject study on technological ventures (Utterback and Rietberger, 1982). That sample consisted of firms started between 1965 and 1975, incorporated in the state of Massachusetts, and whose main business involved the manufacture of

computer hardware, e.g. whole computers, component boards, and peripheral devices. The products of these organizations are based on a relatively high degree of complex and changing technology. The ten firms used for the present research on product strategy were chosen by the convenience that the first author had carried out the earlier multi-subject study interviews with these firms and therefore had access to them for follow-up data collection. The product-related sales of each of these ten firms for 1982 was less than $50 million.

Methods

Several criteria were imposed to determine what constituted a "product". The sample firm had to make each "product" with its own resources, either in part or in whole, and commercialize the product under its own name at some point in time. Consulting work, such as contract R&D, and projects which never resulted in released products were not included in the analysis; nor were "process improvements" which were not themselves marketed as products to the outside world. Even though contract R&D and process improvements may play substantial roles in a firm's overall effort to generate revenues and search out new product opportunities, they were not deemed to be direct aspects of product strategy for the purpose of this pilot study.

The extensive interview process, which, with one exception, was conducted with company founders, relied on a joint determination with interviewees of the levels of newness in both the technological and market dimensions contained in each new product in the respective firm's history. Care was taken to avoid bias of measurement, but a

competitor rating scheme might produce less questionable measures in a larger scale follow-up study. The level of newness was measured relative to all product developent activities undertaken by the firm prior to the specific release of a given product. Therefore, the base against which both technological and market newness were determined grew with each successive product of a firm. The "newness" data were then plotted for each firm on a grid like that of Exhibit 1. A firm that had released ten products over the course of its history would have nine specific points placed appropriately on the grid (one for each product after the first). Data for all ten firms in the pilot study are presented in the Appendix.

The data were processed for analysis in three steps. First, each point on the grid was multiplied by a predetermined set of factors representing levels of technological and market newness. A variety of weighting scales were tested, with each set increasing by different margins for each level of newness (i.e. 1,2,3,4 or 1,3,6,10). The results of the analysis proved insensitive to variations in the several scales tested, albeit the maximum scale range used was one order of magnitude.

The second step was to sum these multiplications for the entire grid of the firm. Also added to this sum was the number of initial key core technologies developed by the firm for its first product, multiplied by the weighting factor for "new, but related" products. This addition accounted in part for those firms which embarked on ambitious startup projects.

The third and last step was to divide this total newness sum by the number of points on the grid, e.g. the number of products

which had been released by the firm. This normalized the data for different numbers of products among the firms, and produced the overall "product newness index" employed in subsequent analyses.

The operational hypothesis was that a firm's strategic focus, as indicated by low product newness index values, would have a significant relationship with a firm's economic performance. To test this hypothesis, a dependent variable representing corporate economic growth was required. The one used for the pilot research is based on annual sales, divided by the age of the firm at each respective year of sales, so as to avoid possible inappropriate bias towards younger fast-growing firms. It was not feasible to collect sales figures for every year of each company. However, the past three years of sales were obtained, and after dividing each yearly figure by the age of the firm at that time, a mean sales growth per year was calculated. For example, the calculation for a ten year old firm whose past three years sales were $4 million, $9 million, and $10 million respectively would be [(4/8 + 9/9 + 10/10)/3] or 0.83. In contrast, a three year old firm with the same sales would have created a growth index of [(4/1 + 9/2 + 10/3)/3] or 3.93. This index serves as the measure of "growth" for the firm, in million dollars per year. Using this growth variable, a broad range of "success" existed in the sample: some firms were strong performers, while others were on the verge of bankruptcy.

In addition to the analyses using the weighted "product newness index", additional tests were also made of possible relationships between corporate growth and each of the two dimensions of "product newness" separately. Factors other than product newness

dimensions, such as entrepreneur characteristics (Roberts, 1966), while possibly relating to company growth, were obviously not tested.

The primary goal of the pilot study was to develop and test an empirical methodology, and not to generate predictive conclusions. A small sample was employed to that end. Nevertheless, the significance is high of the relationship between strategic focus, as reflected in product newness, and corporate growth.

This finding, which holds true for all sets of weighting factors used, was derived from significance testing of the data using Spearman's rho coefficient. The basic procedure is that the cases are first ranked according to the product newness index (in order of low to high) and then ranked a second time by the growth variable (from high to low). The sum of the squares of the differences for these two rankings is the basis for calculating the Spearman coefficient. Exhibit 4 illustrates the rankings and calculations for one of the weighting sets.

In testing for significance, the null hypothesis was that the predictor variable, product newness, would have no statistically significant relationship to the ranking of the firms by commercial success. The alternative to this was indeed the main hypothesis of the study, that firms with high degrees of strategic focus, as reflected in lower product newness indices, would tend to be stronger performers, and those with greater strategic diversity as reflected in high product newness scores would be poor performers.

The coefficient derived from the rank-order relationship tested in Exhibit 4 is .89. For a sample size of ten firms, the coefficient would have to fall below .746 to be not significant at

Exhibit 4

Newness Predicting Growth

Case	Main Product	Product Newness	Rank	Growth	Rank	d_i^2
3	Line Printers	2.75	1	2.73	1	0
2	Large Computers	2.80	2	1.96	2	0
9	Optical Character Reconition Systems	3.11	3	1.72	4	1
4	Portable Terminals	3.18	4	1.29	5	1
7	Perpheral Processors	3.29	5	1.85	3	4
5	Electronic Funds Transfer Terminals	3.57	6	.23	6	0
10	Microcomputer Systems	4.00	7	.01	10	9
8	Tape Calibration Devices	4.25	8	.11	7	1
1	Access Control Systems	4.38	9	.05	9	0
6	Speech Recognition Systems	5.25	10	.06	8	4

$$\text{Spearman's rho}(r_s)^{*} = 1 - \frac{6\sum d_i^2}{n^3 - n} = 1 - \frac{6(20)}{990} = 0.89$$

* From Siegel (1956).

the .001 level (for a one-tail test). The significance of these findings was established by a comparable margin for each of the several sets of weighting factors employed in the analysis. Further, the rank-order method was applied to each dimension separately. The coefficient for the technological dimension was .70, which indicates a significant relationship at the .05 level. The relationship with strategic focus as measured by market newness only was even stronger, with a coefficient of .89.

Next, an effort was made to test the issue of whether it is easier to learn new technologies or to learn new markets. The skewed bell-shaped curve hypothesis was temporarily substituted with an assumption of linearity so that a regression could be performed. As shown in Exhibits 6 and 7 each dimension of newness versus performance appears, on an "eyeball" basis, to support the linear hypothesis. (In fact, the positioning of the first point on each graph further strengthens the untested skewed bell-shape hypothesis.) A regression on the data was performed with Performance, Market Newness, and Technological Newness as the three variables. The R^2, with Performance as the dependent variable, was .63, which was significant at a .03 confidence level using the F-Statistic test (with 7 degrees of freedom).Remembering that there should be a negative correlation between the Newness variables and Performance, the correlation coefficient matrix in Exhibit 5 shows a stronger relationship between low market newness and performance than between low technological newness and performance, as the authors had hypothesized.

Exhibit 5

Correlation Coefficient Matrix for Performance vs. Newness

	Performance	Market Newness	Technological Newness
P	1.0		
M	-0.79	1.0	
T	-0.55	0.59	1.0

The sample includes some companies whose new product strategies have focused specifically on a set of customers, adding new, related key technology to their existing technology to provide "new generations" of a product line to these same customers over the years. This aggressiveness has been combined on occasion with joint development or close consultation with larger opinion-leading customers in the niche, assuring that the "new generation" is "on target" in its functionality and that other customers in the niche pay attention. As an alternative model of product development strategy, other sampled firms have leveraged their existing key technology into new niches and segments. An example might be an "intelligent" terminal company which, by buying several peripheral devices and licensing systems software, can market a "personal computer". Technology improvement is relatively minor; the identification of specific user needs required to customize the technology, and the development of appropriate distribution and support mechanisms can, on the other hand, be major undertakings.

Exhibits 6 and 7 display the sample data in terms of the newness versus performance hypotheses. While the sample is too small for rigorous testing of the "skewed bell-shape" hypothesized relationship, the curves at least satisfy a "rough-cut" sense of appropriateness. Exhibit 8 displays the performance measures for each company used as labels for the Technology and Market Application intersections for each firm. The grouping of the relatively high performing firms in the lower left quadrant of the grid is indicative of the trend asserted in the hypothesis.

Exhibit 6

Technological Newness versus Performance

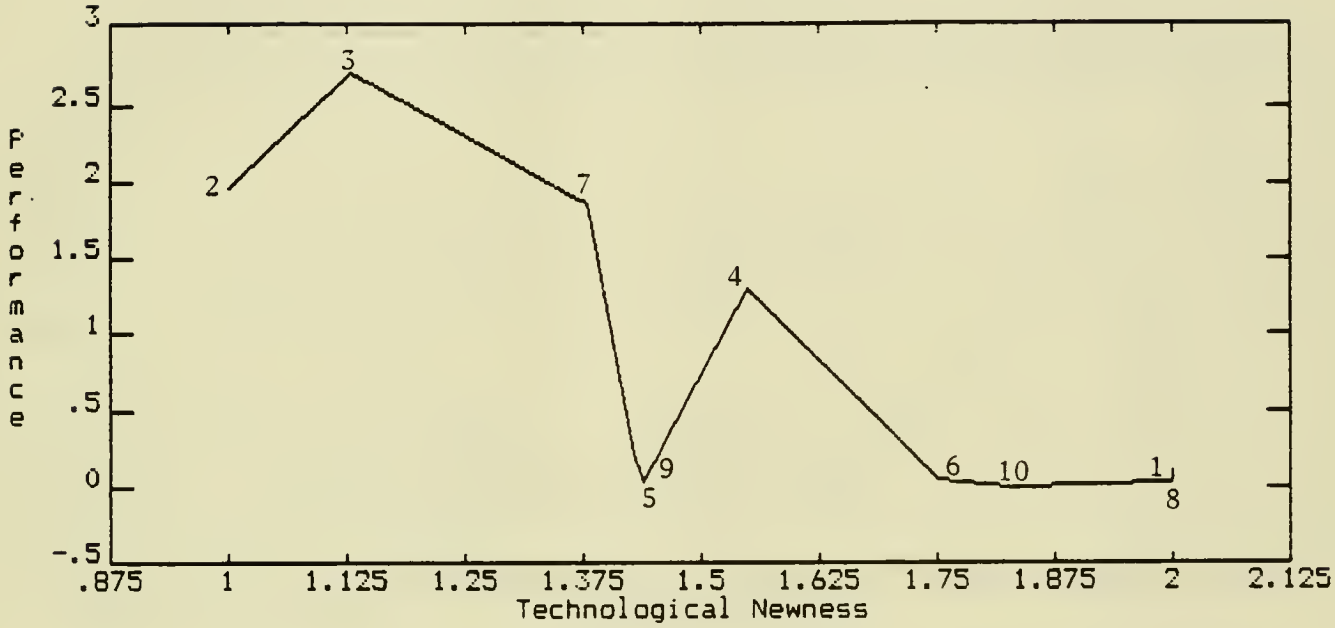


Exhibit 7

Market Newness versus Performance

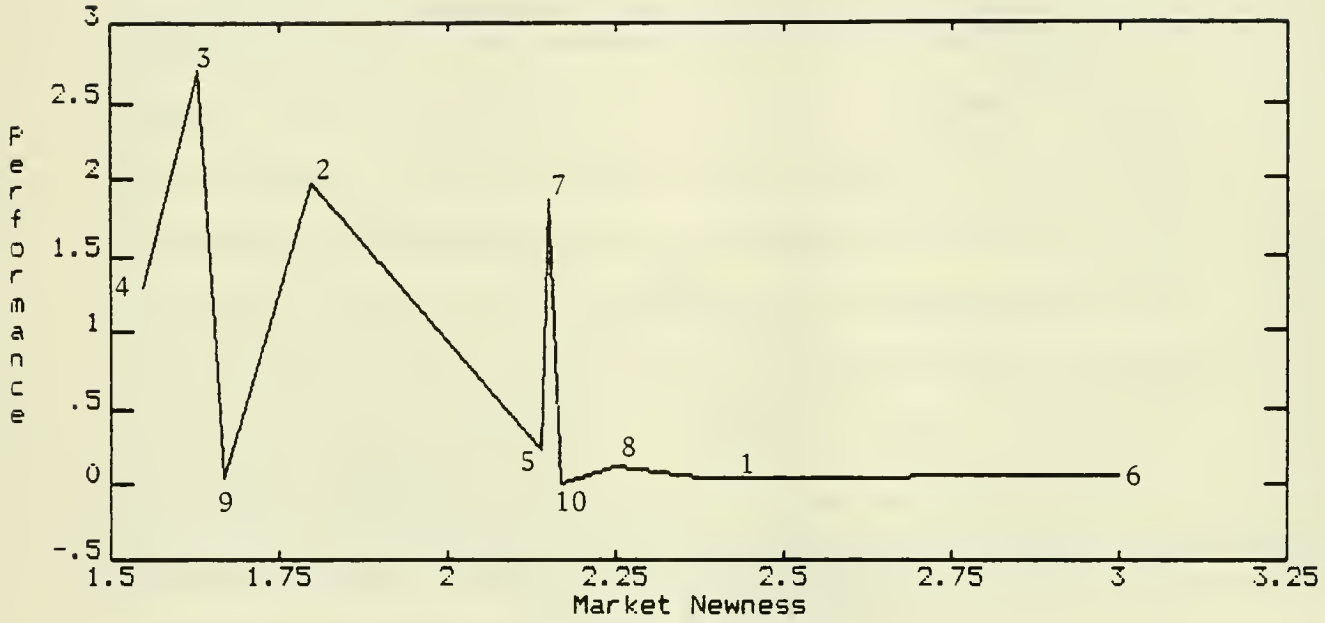
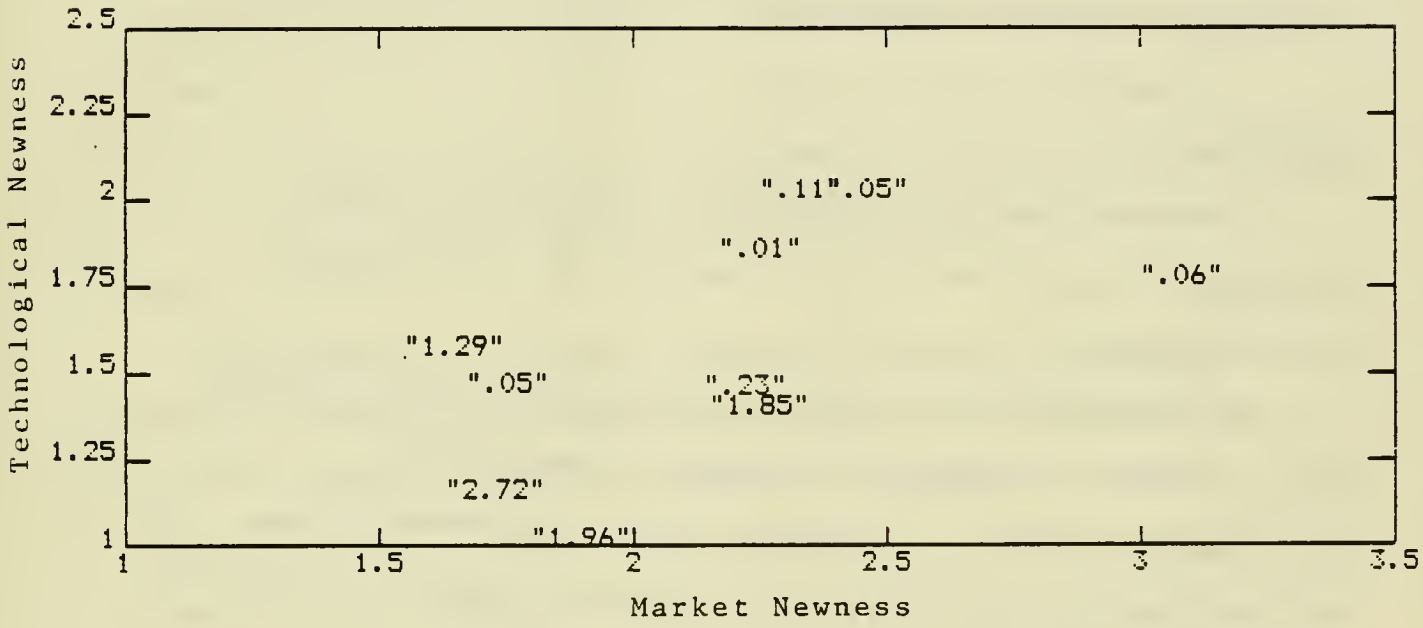


Exhibit 8

Company Performance Plotted on Market/Technology Positions



A final test was performed to see whether the number of products alone that each company produced might independently explain company performance. A coefficient of correlation was derived on rank-ordered pairs of total products and performance. In neither possible direction (i.e. the more products, the better the performance; or the fewer products, the better the performance) was the Spearman coefficient significant (0.19 and -0.22, respectively).

Discussion

These empirical results served as a foundation for further examination of the strategies of the ten firms and of the research methodology itself.

As stated above, the result of the analysis was that strategic focus as manifest in lower levels of product newness had an observable relationship with corporate economic performance. Firms that over the course of their evolution primarily remained in one key technology area for applications in familiar markets tended to outpace those which did not. Implied within this finding is that successful firms tended to choose a growth-sustaining core technology to begin their product development activities, thereby avoiding the high levels of product line diversity which would accompany a switch from an ill-fated technology to a new, more promising one.

The sample contained firms whose activities centered on a single core technology from startup to the present time, as well as companies which redirected their energies into new areas in order to remain in business. A descriptive portrait of a "good" initial key core technology which emerged from conversations with the entrepreneurs was that the technology needed to be challenging to implement, difficult enough so as to present a significant barrier to

entry for would-be competitors. Also the key founders required a clear perception or vision of how to achieve distinctive functionality in a sequence of future products utilizing the initial key technology.

More specific growth strategies were suggested from the interviews. One effective strategy was that firms that developed products for new market segments or general markets were most successful if they leveraged their efforts on existing proprietary key technology. This could be accomplished by combining an existing key technology with new types of components to generate the new product.

For example, in the sample were two firms each of which had developed technologically similar desktop microcomputer systems. One of these companies was able to leverage its "intelligent" input/output (I/O) controller board technology into the new product by purchasing or licensing all the necessary additional elements. This included the CPU, memory components, the Winchester disk, the CRT display, and the operating system which were assembled together with a specialized I/O controller board. The microcomputer was marketed a year and a half after its formal project initiation to systems integrators and software developers, many of whom were existing customers of the I/O controller board line.

The second firm, on the other hand, did not leverage its existing key technology. Its main product was a line of magnetic tape head calibration instruments sold to computer manufacturers. Even though the firm acquired all the necessary hardware components from outside vendors, it chose to develop both its own proprietary operating system and a set of business applications packages.

Additionally, the new product was targeted, rather unsuccessfully, for retail distribution. The level of diversity represented by the firm's actions was therefore high, falling into Region 6 in Exhibit 1 as compared to the Region 3 pursuits of the first firm described above.

A larger sample, now being gathered in a follow-on study, would provide the data required better to examine specific strategy alternatives. Further, although the analysis methods presented in this article produce a "focal point" of the firm's degree of focus, equally important insights may be found in the measurement of the variance around that focal point. Time dependent movement upon the grid is another possible technique for examining the strategy of the firm. Additionally, one might be interested in the portability of the authors' experimental results concerning strategic focus and performance to larger firms. With these thoughts in mind, the framework and methods presented in this pilot analysis may serve as tools for continued research on new product strategy in the high technology firm.

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Appendix: Product Newness Data

COMPANY	PRODUCT	Technology					Market Applications			
		New Key Core	Some Minor	Some Major	New Related	New Unrelated	Existing Users	New Niche	New Segment	New Market
1	1	x							x	
	2	x				x				x
	3			x			x			
	4		x					x		
	5	x			x				x	
	6			x				x		
	7		x					x		
	8	x			x			x		
2	1	x							x	
	2		x				x			
	3		x						x	
	4		x				x			
	5			x			x			
3	1	x							x	
	2			x			x			
	3		x					x		
	4		x					x		
	5		x					x		
	6			x			x			
	7		x				x			
	8		x				x			

COMPANY	PRODUCT	Technology					Market Applications			
		New Key Core	Some Minor	Some Major	New Related	New Unrelated	Existing Users	New Niche	New Segment	New Market
4	1	x							x	
	2			x			x			
	3			x				x		
	4		x				x			
	5		x				x			
	6		x				x			
	7	x			x			x		
	8		x				x			
	9	x				x		x		
	10		x					x		
	11		x				x			
5	1	x							x	
	2			x				x		
	3	x			x				x	
	4		x				x			
	5			x				x		
	6		x				x			
	7		x						x	
6	1	xx								x
	2	x			x				x	
	3			x				x		
	4			x					x	

COMPANY	PRODUCT	Technology					Market Applications			
		New Key Core	Some Minor	Some Major	New Related	New Unrelated	Existing Users	New Niche	New Segment	New Market
7	1	x							x	
	2			x				x		
	3			x				x		
	4		x					x		
	5		x					x		
	6			x				x		
	7		x					x		
	8			x				x		
	9		x					x		
	10		x					x		
	11		x					x		
	12			x			x			
	13			x						x
8	1	x							x	
	2		x					x		
	3		x					x		
	4			x			x			
	5			x			x			
	6	x			x				x	
	7	x				x				x
	8	x			x			x		
9	1	x							x	
	2	x			x		x			
	3		x				x			
	4			x				x		
	5		x					x		
	6		x					x		
	7		x				x			
	8		x					x		
	9				x		x			

COMPANY	PRODUCT	Technology					Market Applications			
		New Key Core	Some Minor	Some Major	New Related	New Unrelated	Existing Users	New Niche	New Segment	New Market
0	1	x							x	
	2	x			x				x	
	3			x				x		
	4	x			x				x	
	5		x				x			
	6			x			x			

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